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A MODEL TO DESCRIBE PROPELLANT FRAGMENTATION AND ENHANCED BURNING

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We need a model to describe fragmentation and the subsequent enhanced burning for our computer simulations of rocket motor fall-backs and of various instrumented large-scale tests reported at the previous two meetings of this subcommittee. We wanted to make the model as simple as possible, and to require minimal computer time and memory. When we use our ignition and growth model, which describes the decomposition and energy release of propellants during impact, the gas-phase products produce a positive pressure during expansion. Tensile stresses do not develop. Therefore, we cannot use a model based on tensile stress for fragmentation. Instead, we use a model based on deformation as measured by the equivalent plastic strain.

A qualitative observation of large-scale impacts is that the number of pieces from a large-scale impact is the same as the number that results from a geometrically similar small-scale impact at the same velocity. If so, the fragment size is inversely proportional to the strain rate. We must consider scaling when we try to extend results for the impact of 8-g samples to predict the results from impacts of 50-Mg rocket motors.

We calibrated our model by comparison with shotgun impact tests of several Class 1.3 propellants. From those results, we infer that the local surface-to-volume ratio was approximately linear in the local plastic strain. To an extent, this model is reminiscent of models of comminution in which the particle size decreases with increasing work. We must use tests at more than one size to evaluate the dependence on strain rate. Limited comparison of shotgun tests with the impacts of larger propellant samples (4 kg) shows that the dependence on strain-rate is approximately linear.

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